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Development of a Separation Solution for Braided Polyester/Polyolefin Ropes and Lines

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Development of a Separation Solution for Braided Polyester/Polyolefin Ropes and Lines

Predominantly trawls- nets
Contaminating materials:
Anchors, cables, metal chains, fire hoses, etc.

Predominantly gillnets
Contaminating materials:
Lead lines, PE/PP swim lines, wood, mussels, fish fragments, etc.

Ropes and trawl nets
No Contaminants
Metal, buoys/swimmers, organic material removed

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Sponsors: Net Your Problem

Spring 2021
1.1 Executive Summary

The following report summarizes the research performed for the project sponsored by Net Your Problem. The research focuses on using depolymerization reactions as a method of separating polyester from polyolefin material in braided lines commonly used in the fishing and crabbing industries. Currently the mixed fibers in these lines are too comingled to be separated by conventional mechanical recycling methods. The glycolysis reactions were chosen to take advantage of the very different solubilities of polyester and polyolefins. Ethylene glycol breaks down the PET into oligomers and BHET monomer while leaving the polyolefins unreacted. The products of the reaction can then be poured into water which solubilizes the polyester material and leaves the polyolefins floating on the surface.

Two glycolysis reactions were performed over the course of this research. The first was in a 2L batch reactor with no catalyst and the second was in a smaller round bottom flask with 5 mass% NaOH catalyst to polyester. DSC was used to quantify polyester and polyolefin content in the lines and products of the reaction. TGA was used to quantify contaminants and identify oligomeric polyester in the products. FTIR was used to identify functional groups of polyester, polyolefins and solvents in the products.

The primary goal of this research is to develop a method of separating the polyester and polyolefins so that there is less than 5% contamination in each material, allowing them to be recycled. If the contamination metric is reached by this process, the oligomeric polyester and BHET that was formed could be resynthesized into virgin polyester, and polyolefin material could be processed into a new product. Ideally these materials will be used to create products used in the fishing industry to incentivize fishermen to recycle their derelict fishing gear.

2.1 Introduction

Marine plastic is a huge environmental issue, currently 8 million tons of plastics are added to our oceans every year [1]. These plastics destroy ecosystems by killing marine wildlife through ingestion, suffocation, or entanglement. Solar UV radiation breaks up ocean plastics into micro and nanoparticles that end up in the food and beverages we consume and can cause a whole host of health problems such as cancer, reproductive, developmental, and immune system issues [1]. Plastic materials also contribute to global warming and greenhouse gases because they are generally petroleum-based and release carbon dioxide when they are incinerated as waste. [1]

Plastic recycling is a major solution to the plastic waste problem, as it reduces the need for virgin plastics and creates a market for materials that would usually end up in a landfill or ocean. Although, recycling is not without problems of its own. Materials need to be cleaned and size reduced before recycling which requires a lot of water and energy. Recycled plastics are often associated with having worse mechanical properties than virgin plastics due to contamination and thermal degradation. Manufacturers are typically more skeptical of the quality of recycled materials because they do not know what the original material was used for and how contaminated it may be. It is difficult for recyclers to characterize the quality of recyclates with low tolerances, thus making it challenging to compete with manufacturers of virgin plastics who
can clearly cite the properties of their materials. Additionally, materials need to be properly separated and sorted before they can be recycled. Many products are made of blends of different plastics which can make them costly or impossible to recycle. [2]

The specific problem this research addresses is that there is currently no recycling solution for Polyester (PET) / Polyethylene (PE) gillnet cork line. The comingled PET and PE fibers are too challenging to separate by conventional recycling methods. Because these ropes are used in the fishing industry and cannot be recycled, they are often littered into the ocean. Currently there is a lack of oversight to ensure that fishing companies have waste management systems in place, and ports do not currently have a central role in assisting in waste management activities. [3] Recyclers typically pay around 25-35 cents per pound for used nets that are clean. If the nets have debris or are unrecyclable, such as the gillnet cork line this research is focusing on, the supplier is charged about 4 cents per pound. [4] If a recycling solution can be found for this rope, fishing operations can save money by selling used materials to recyclers and other businesses can use the recycled PET and PE in their manufacturing process to reduce the amount of material in the plastic waste stream.

The main sponsor for this research project is Net Your Problem. Their mission is to find recycling solutions to products commonly used in the fishing industry such as nets, fishing line and buoys. They connect fishing operations with recyclers so after fishing gear is used, the materials can be recycled. [5] The fishing gear received from net your problem is processed with other materials to produce 50 to 100 metric tons of material per week. The problem is any DFG that has polyester/polyolefin fiber blends renders current recycling methods useless. Developing a method for recycling this type of DFG is desirable not only from an environmental perspective, but also because at the base of these thermoplastics are valuable raw materials that could be used to produce high quality goods. If a recycling solution can be achieved for these mixed lines, then the types of material NYP can accept will increase benefiting multiple involved parties. The recycling companies Nicole Baker works with are excited for new information on this type of DFG and one of the companies PLASTIX in Denmark also is working with a university to do research on recycling polyester/polyolefin fiber blends. [6]

The primary goal of this research is to develop a method for separating PET and PE from gillnet cork line with the requirement that the final material(s) have less than 5% contamination after performing the separation method. For the purpose of this research, we are defining contaminants as any material that is not PE for the separated PE mixture, and any material that is not oligomeric PET for the depolymerized PET mixtures. If less than 5% contamination can be achieved in a timely manner, an additional goal is to determine optimal batch reaction process parameters to ensure high repeatability.

3.1 Solution

Because the goal of this research is to develop a process that can be used in the recycling industry, it is important that our process separates the materials so that they have less than 5% contamination of any other materials by mass in each mixture. The process should also have a
high recovery rate and repeatability, and low cycle times and added materials. These requirements were used to gauge the effectiveness of potential solutions to the problem.

This project can be divided into two major categories: process design and characterization design. For the process design, we need have determined the reaction mechanism we will use to separate the materials and what method we will use to perform the reaction. For the characterization design we have determined how we will quantify the contamination, degree of separation, recovery, and repeatability of our chosen process.

3.2 Reaction Method

Due to the highly different solubilities of PE and PET, we investigated performing solvolysis reactions to breakdown PET while leaving PE unreacted. Out of all possible reactions, we chose to focus on hydrolysis and glycolysis because these two reactions are currently applied in industry for PET recycling and require less toxic or corrosive materials than other potential solvents.

The reaction we determined to move forward with is glycolysis because it has less safety considerations and lower cycle time, although hydrolysis only requires water as a solvent and glycolysis requires ethylene glycol. Glycolysis has a lower cycle time because it can be performed at higher temperatures due to the high boiling point of ethylene glycol. Hydrolysis requires water as a reactant that has a low boiling point so the reaction would need to occur under 100°C to prevent increased pressure due to volatilization that is a safety hazard. At low temperatures hydrolysis would have very long cycle times. Glycolysis's products (BHET and EG) are versatile compared to that of hydrolysis, in that they can be synthesized into saturated and unsaturated polyester.

The glycolysis reaction will take place in a batch reactor, at elevated temperature, and in the presence of the reactant ethylene glycol and sodium hydroxide catalyst. The batch reactor will be open to atmospheric pressure to eliminate buildup of pressure from any residual water or other volatiles and a condenser will be used to collect off gassing as the reaction proceeds. More details about the reaction set up and process parameters are provided in the following section.

3.3 Process Design

The glycolysis reactions will consist of mixing the granulated PET/PE lines with EG in a 2-liter batch reactor with a 10:1 (EG:PET) mass ratio and varying weight percentages of sodium hydroxide acting as a catalyst. To ensure this ratio and the correct weight percent of catalyst is achieved an estimated mass of PET in the unreacted fiber mixture will be determined using a Heat Flow vs. Temperature plot to compare the melt peaks from initial DSC experiments of the PET/PE material. The combined reactants will be heated in the 2-liter batch reactor at 190°C for 120 minutes and immediately after the reaction takes place the products will be poured into cold water, then filtered through a metal screen to collect the solid PE and any unreacted PET. The liquid phase will then be vacuum filtered to separate the solid phase consisting of PET oligomers from the liquid phase (consisting of EG and BHET monomer and catalyst).
The procedure for this reaction was follows the general procedures used in other PET glycolysis reactions [33] [35]. The first reaction will be the control with 5% weight catalyst to PET. This is our control because in previous research into optimizing the depolymerization of PET with glycolysis 100% conversion of PET was not achieved without long reactions times (8+ hours) when not in the presence of a catalyst. [35] [33] In this research 100% conversion was achieved with 5% catalyst in the PET ethylene glycol mixture after 4 hours at only 180 C and a 4:1 ratio (EG:PET). [35]

If these initial experiments with the batch reactor prove to be successful at separating the materials with less than 5% contamination, the process can be optimized for repeatability and max recovery. This can be done by tailoring equipment to filter the three different product mixtures, how we contain them, or modifying the reaction vessel. Additionally, because there is currently no research on using glycolysis as a separation method, the early experimental trials with the batch reactor will allow us to determine if our hypotheses on the physical state (solid, liquid, miscibility) of the products is correct. If the initial batch reaction methods are successful at separating the materials with high repeatability and recovery of the products the reaction could be done in a twin-screw extruder giving a reaction vessel and a more continuous and likely repeatable process.

3.4 Characterization and Testing

To ensure that our separation process is efficient and effective, we need to first quantify the relative masses of PET and PE in the shredded rope. Then after the experiments are performed, identify the products, quantify % contamination, degree of separation, recovery and repeatability.

3.4.1 Initial DSC

Before any reactions can take place, initial DSC runs on the shredded rope needs to be performed to confirm the relative masses of PET and PE. The melt peaks can be integrated using TA universal analysis to determine the mass% of the two materials.

3.4.2 Identification of products

After glycolysis is performed there will be 3 mixtures of materials separated. Hypothetically these mixtures should be unreacted PET and PE (mixture A), oligomeric and dimeric PET (mixture B) and EG and BHET monomer (mixture C). If separation of mixture A is possible with flotation, the separated materials can be identified via FTIR and will be attempted, but also a DSC to determine loss of mass will be ran. Mixture B and C can be identified by FTIR by the size of the peak for the O-H functional group.

3.4.3 Contamination

TGA will be performed on the products to determine the presence of any contaminants that are not a reactant or product of the reactants. The degradation temperatures of the polymer materials in mixtures A, B, and C are well tabulated values and curves so any other degradation
temperature would give a clear indication of outside contaminants not being washed or reacted away. If unexpected degradation events are detected by TGA, the transitions can be integrated to find the relative mass percent of these contaminates in the known materials.

DSC will be performed on the solid product to estimate the mass of PET that is present if any. This mass can be divided by the original mass to get a % contamination from the PET not depolymerizing to its oligomeric form.

If there is more than 5% contamination that mixture of material will not be recyclable and will either need to be repurified, or the procedure of the reaction will need to be reconsidered so that there are less contaminates present.

3.4.4 Separation

If mixture A can be separated via flotation, a density test can be performed on the PET and PE to determine how much of one material is still conmingled with the other. Because density follows the rule of mixtures, the density of the material can be compared with the known density of the materials and the relative amount of each material can be calculated via weighted averages. If the materials are determined to be more than 95% pure, they can be recycled and considered successfully separated materials. If mixtures B and C are determined to have less than 5% contamination, they can be purified and usable material for the synthesis of PET. If this is the case, they can also be considered recyclable material that was successfully separated.

4.1 Methodology

4.2 Sample Prep

Before the depolymerization reactions and characterizations could take place, the shredded lines needed to be cleaned, dried, and size reduced. The lines were soaked with hot water and scrubbed clean. Next, they were left out to dry for eight hours under an IR heater lamp. Finally, they were size reduced in a granulator. The consistency of the final material ready for reactions was a well-mixed fluffy powder.

Figure 1: Shredded rope after being washed and dried
4.3 Estimating PET content

To calculate the amount of ethylene glycol and NAOH required for the depolymerization reaction, the weight percent of PET in the granulated lines needed to be estimated. 5 heat-cool-heat DSC experiments were performed on the granulated lines. A ramp rate of 10 °C/min was used to heat the sample from room temperature to 300 °C from room temperature and to cool it back to room temperature. The melt peaks of the polyolefin and PET content were integrated to determine the melt enthalpy of each material. The melt enthalpy of PET was divided by the total melt enthalpy of the mixture to estimate the mass percent of PET. This experiment was performed on 5 samples and the average mass percent of PET was calculated.

4.4 Reaction 1

The first depolymerization reaction was performed in a 2L batch reactor. 100 grams of granulated lines were reacted with 800 grams of ethylene glycol and no catalyst was used. The mixture was heated to 190 °C and a condenser and mechanical stirrer were used. The reaction was carried out for 2 hours. At the end of the reaction the liquid mixture was poured into cold water and then filtered through a metal screen. The resulting liquid mixture was then vacuum filtered using a Buchner funnel and fine filter paper. The solid material that was filtered out was dried using UV heater lamps and the water was evaporated out of the liquid mixture in a beaker heated to 110°C.
4.5 Characterizations

DSC was performed on the three mixtures (large solid filtered out using metal civ, small solids using vacuum filtration, and the liquid mixture). 3-5 heat-cool-heat experiments were performed at a ramp rate of 10 °C/min from room temperature to 350 °C. Melt temperatures and integrals of the melt peaks were analyzed to estimate PET, Polyolefin, oligomer, and solvent content in each mixture.

TGA was used on both solid mixtures to quantify contaminants and provide additional evidence for oligomeric PET content. 3-5 ramp experiments were performed from room temperature to 650 °C. Degradation events and temperatures were analyzed to provide evidence for oligomeric PET content and estimate weight percent of contaminants, solvents, PET and polyolefins.

FTIR was performed on all three mixtures to identify functional groups. 3-5 FTIR spectrum were generated for each mixture using 32 scans and a resolution of 1 inverse centimeter. The spectrum was analyzed looking for typical peaks of polyester and polyolefin content.

4.6 Reaction 2

After the first reaction the 2L reaction vessel was damaged by another research team, so a 3-neck round bottom flask was used for the second reaction. 5 grams of material was mixed with 100-mL of ethene glycol in the flask. Then, 0.055 grams of NAOH catalyst was diluted in water and added to the flask. The flask was heated in an oil bath to 190 °C and a condenser and magnetic stir bar were used. The reaction proceeded for 2 hours, then the material was poured into cold water and filtered through a large Buchner funnel. The solid material was floated in a bucket of water to separate the polyolefin and PET materials, then dried under UV lamps. The liquid mixture was vacuum filtered, and the solids filtered out were dried under UV lamps and the water was evaporated out of the liquid mixture in a beaker heated to 100 °C.
Figure 4: Setup for reaction 2 with 3 neck round bottom flask in a heated oil bath with a condenser.

Figure 5: Separating the polyolefins and PET via flotation
5.1 Results

5.2 Initial Characterizations of the shredded rope

The DSC on the granulated lines showed 3 melt peaks at 133 °C, 163 °C, and 250 °C, corresponding to the melt temperatures of PE, PP and PET. The average melt enthalpy of PET was divided by the average total melt enthalpy to estimate 20.8 mass% PET content. The TGA showed one degradation event at 380 °C which was likely the 3 polymers degrading at similar temperatures. The TGA also showed that there was 4.8% non-PE/PP/PET content, and all the water was dried out in the sample preparation step.

![DSC on granulated lines](image)

**Figure 6: DSC on granulated lines**

**Table 1: DSC results on granulated lines**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Tm1 (°C)</th>
<th>Tm2 (°C)</th>
<th>Enthalpy Tm1 (J/g)</th>
<th>Enthalpy Tm2 (J/g)</th>
<th>Enthalpy Tm3 (J/g)</th>
</tr>
</thead>
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<tr>
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<td>165.93</td>
<td>251.43</td>
<td>27.1</td>
<td>40.06</td>
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<tr>
<td>2</td>
<td>130.9</td>
<td>161.19</td>
<td>251.83</td>
<td>36.11</td>
<td>40.01</td>
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<tr>
<td>3</td>
<td>136.23</td>
<td>166.61</td>
<td>252.44</td>
<td>26.26</td>
<td>33.02</td>
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<tr>
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<td>130.73</td>
<td>161.05</td>
<td>250.81</td>
<td>30.05</td>
<td>31.81</td>
</tr>
<tr>
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<td>161.06</td>
<td>246.64</td>
<td>32.78</td>
<td>35.81</td>
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<tr>
<td>Average</td>
<td>133.132</td>
<td>163.168</td>
<td>250.63</td>
<td>30.46</td>
<td>36.142</td>
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</table>
5.3 Reaction 1 Polyolefins

The DSC, FTIR and TGA results on the products of the first reaction are shown below. The DSC experiments on the solid polyolefin material showed two melt peaks at 132 °C and 163 °C. These melt temperatures are consistent with the melt temperatures of polyethylene and polypropylene, and now melt peak at PET’s melt temperature were found in any of the DSC experiments of this material. The TGA results showed 2 degradation events on the polyolefin material. One from around 100 – 200 °C, consistent with the degradation temperatures of water and ethylene glycol, and one at around 400 °C, the degradation temperature of polyethylene and polypropylene. The FTIR results for this product also showed evidence of aliphatic content around 3000 inverse cm and little to no evidence of O-H or ester content.
Figure 9: DSC cool and heat cycle of polyolefin solid product showing no melt temperature for PET

Table 2: Polyolefin crystalline melt temperatures and enthalpy change

<table>
<thead>
<tr>
<th></th>
<th>Tm1 (°C)</th>
<th>Tm2 (°C)</th>
<th>Enthalpy Tm1 (J/g)</th>
<th>Enthalpy Tm2 (J/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>132.78</td>
<td>161.48</td>
<td>32.08</td>
<td>48.43</td>
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<tr>
<td>2</td>
<td>129.72</td>
<td>161.2</td>
<td>38.23</td>
<td>47.04</td>
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<td>3</td>
<td>134.37</td>
<td>166.83</td>
<td>12.7</td>
<td>9.58</td>
</tr>
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<td>4</td>
<td>132.39</td>
<td>162.69</td>
<td>33.37</td>
<td>47.07</td>
</tr>
<tr>
<td>Average</td>
<td>132.315</td>
<td>163.05</td>
<td>29.095</td>
<td>38.03</td>
</tr>
</tbody>
</table>
5.4 Reaction 1 oligomeric mixture

The DSC for the oligomeric PET mixture showed two melt peaks, one at 109 °C and another at 233 °C, consistent with the melt temperatures of BHET and PET. The TGA results for the oligomeric mixture showed 4 degradation events, one between 100 – 200 °C, one at 210 °C, another around 400 °C, and a final broad degradation event at about 500 °C that showed material still degrading at the maximum temperature of 650 °C. The FTIR spectra showed typical peaks for PET material. A broad peak at 3400 inverse cm, indicative of O-H bonds, and a strong peak at 1750 inverse cm typical of ester linkages.
Figure 12: Separated oligomeric PET

Figure 13: DSC heat and cool cycle for solid oligomers product displaying Tm of monomer at 109.07 and broad 228.48 rather than sharp for PET
Table 3: Oligomer product melting temperatures and enthalpy changes showing a large amount of PET being converted to monomer

<table>
<thead>
<tr>
<th>Sample</th>
<th>Tm1 (°C)</th>
<th>Tm2 (°C)</th>
<th>Enthalpy Tm1 (J/g)</th>
<th>Enthalpy Tm2 (J/g)</th>
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</thead>
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<td>228.48</td>
<td>131.4</td>
<td>160.6</td>
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<td>109.69</td>
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<td>130.8</td>
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<td>114.34</td>
<td>236.34</td>
<td>39.98</td>
<td>13.03</td>
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<tr>
<td>4</td>
<td>103.36</td>
<td>232.68</td>
<td>121.3</td>
<td>232.68</td>
</tr>
<tr>
<td>Average</td>
<td>109.115</td>
<td>233.54</td>
<td>105.87</td>
<td>111.17</td>
</tr>
</tbody>
</table>

Figure 14: Tg of Oligomeric mixture

Figure 15: TGA ramp experiment on oligomeric PET mixture
5.6 Reaction 2 Polyolefins

Similar to the results for the polyolefins in the first reaction, the DSC samples for the polyolefins in reaction 2 showed 2 melt temps at 130 and 160 °C, typical melting points of polyethylene and polypropylene. None of the samples showed any sign of polyester being present. The TGA showed 2 degradation events, one between 100 and 200 °C, likely due to EG and water and one around 350 °C due to the polyolefins. Less than a percent of mass remained after the material was heated 650 °C. The FTIR spectra also showed strong peaks around 3000, indicating high aliphatic content and no strong signals at 3400 or 1750 which are typical in PET and BHET spectra.
Figure 18: DSC of solid polyolefin product with two Tm’s corresponding to HDPE and PP

Figure 19: TGA results for polyolefin products
5.7 Reaction 2 Solid Polyester

The DSC results for the PET products showed expected Tg’s, Tm’s and Tc’s of PET with no additional melt peaks. The TGA results for this material did show an additional degradation temp beyond the degradation temperature of PET (around 400 °C) at 515 °C with about 16% of non-PET material. The FTIR showed a strong peak at 1750 inverse cm, indicating high ester content and no strong peaks in the 3000 or 3400 range.

Figure 21: Solid products from reaction 2, Polyester is white, Polyolefins are reddish brown
Figure 22: DSC of solid separated polyester product showing Tg, Tm, and Tc as expected

Figure 23: TGA results for solid PET product

Figure 24: FTIR spectra of solid polyester with expected peaks
5.8 Reaction 2 Oligomeric Mixture

Unfortunately, the DSC instrument broke down during the runs on the oligomeric mixture and the remaining material was used for TGA and FTIR so no DSC data could be gathered on these products. Similar to the TGA results for the PET products in reaction 2, the degradation temp for PET at 400 °C was found with an additional degradation temp at about 500 °C. Both TGA results showed about 16% of non-PET material was present. The FTIR spectra showed the strong peak at 1750 inverse cm for ester content and a small peak at 3400 which is typical for oligomeric PET due to the larger concentration of hydroxyl end groups.

Figure 25: Dried oligomeric PET material
6.1 Analysis

The process successfully achieved a high degree of separation of PET and polyolefins at a minimal cost by utilizing equipment that was available in the lab. The separation is indicated in both the DSC and FTIR results in both reactions. The oligomeric PET products in both reactions and the unreacted PET in the second reaction showed no melt events around 130 – 160 °C which is evidence that there was no polyolefins present. Additionally, the polyolefins in both reactions showed no evidence of PET content in the FTIR or DSC results. In reactions 1 and 2, the TGA results showed the solid polyolefin products had less than 5% contamination which meet the contamination standards, meaning the material is pure enough to be recycled.

The TGA on the oligomeric solid product from the first reaction had 3 mass loss events from water/EG, BHET monomer, and PET. The FTIR showed a strong O-H peak around 3400 cm$^{-1}$. In the second reaction the soled PET products had an additional degradation event around 500 °C which could be due to secondary reactions between forming with the sodium from the
sodium hydroxide. The oligomeric mixture in the second reaction also didn’t show any degradation event at 210 °C (the degradation temp of BHET) which means that little to no PET was converted into BHET. This was likely due to issues bringing the material up to 190 °C in the second reaction. For most of the reaction the material was at 170 °C. The TGA results showed around 16% contamination for this material in both reactions, meaning the material needs to be further purified before it can be polymerized into PET.

Although the polyolefins were able to be separated with low enough the contamination to be recycled this process can still be improved. The cycle time for the process as it currently exists is very long with multiple drying steps and a 2-hour reaction time making it costly. The reaction was also not able to separate the oligomers or polyester to less than 5% contamination which may have been due to the catalyst bonding to the PET and creating new molecules. However, an important takeaway from this research is that PET and polyolefins can be separated based on their very different solubilities. If no catalyst was used and the materials were solubilized in EG or water at elevated but much lower temperatures than required for depolymerization, the materials may be able to be separated without altering their chemical state, drastically decreasing the cycle time required for separation.

7.1 Future Work

Moving forward, researchers should decide whether to continue optimizing the depolymerization reaction as a method of separating the polyolefins from the PET or attempting to separate based on solubility. If the depolymerization method is preferred, more small-scale reactions should be performed with varying amounts of catalyst to determine the effect catalyst has on converting PET to BHET. More TGA, FTIR and DSC data need to be collected at all levels of the process to better understand the materials in each phase. HPLC should also be used on the final liquid mixture from the process to determine if oligomers or monomers are present in this material. If separation based on solubility is chosen to be investigated, researchers should perform experiments with different solvents, temperatures and mixing methods to determine the best parameters for de-mixing based on solubility. DSC, TGA and FTIR should be used to gauge the effectiveness of the process, similar to how it was used in the depolymerization method, and chromatography can be used to ensure the polymer is not depolymerizing at elevated temperatures in the chosen solvent.

8.1 Conclusion

Overall, the process developed in this research was successful. The polyolefins were able to be separated from the PET with less than 5% contamination, meaning they can be recycled. However, the implementation of the proposed research plan was not without its challenges. The reaction vessel and DSC instrument breaking prevented us from collecting as much data as we had intended. The oligomeric PET was not able to be separated with less than 5% contamination in either reaction, but it was shown that PET and Polyolefins can be separated based on their different solubilities. Moving forward, more research needs to done investigating the effects of adding catalyst to the reaction, and gathering more data on reactions with better controlled temperatures.
9.1 Bibliography


